National Institute of Biomedical Imaging and Bioengineering

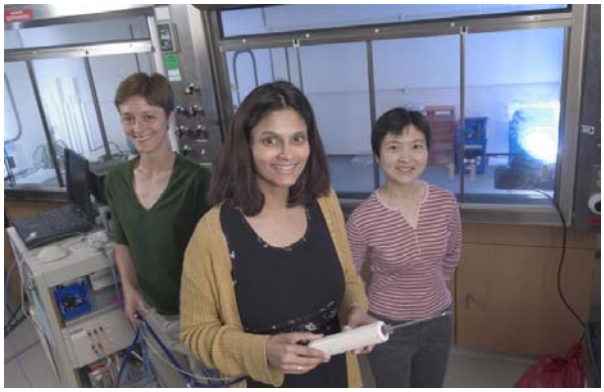
Optical Probes May Improve Breast Biopsies

To find out if a breast lump is cancerous, patients often undergo a core needle biopsy. One million such diagnostic procedures are performed annually in the United States. A doctor uses X-ray or ultrasound images to locate the suspicious tissue and then retrieves tissue samples with a hollow biopsy needle. The procedure is less invasive, less expensive, and faster than surgical biopsies. Its downside, however, is a false negative rate of up to 7 percent.

To improve the accuracy of the test, the biopsy needles can be fitted with a tiny fiber-optic probe to detect malignant tissues, according to studies by NIBIB grantee Dr. Nirmala Ramanujam, assistant professor of Biomedical Engineering at the University of Wisconsin-Madison, and her student Carmalyn Lubawy.

Information-Rich Light

The probe emits near-infrared light into the breast tissue, and then collects and analyzes light that the tissue does not absorb. The difference in the absorption of light between the tumor and the normal tissue is due to differences in the blood content and the oxygenation of the blood in the tumor, as well as the tumor's water and lipid content. Other components of tissue such as cells, subcellular components, and collagen fibers scatter light; the differences in light scattering between tumors and normal tissue can also be used to diagnose cancer. By monitoring what happens to the light as it travels through tissue, the researchers capture structural and physiological information that indicate whether the needle has hit its mark in the malignancy. "With this particular technology, we are doing analytical chemistry in the body," Dr. Ramanujam says.



Dr. Nirmala Ramanujam (holding biopsy needle, center) and graduate students Carmalyn Lubawy (left) and Changfang Zhu have developed an optical probe to help doctors biopsy breast tissue more accurately. The probe slides into the hollow biopsy needle doctors currently use.
Photo by David Nevala.

Most optical devices use continuous light, but this fiber-optic probe emits light that dims and brightens rapidly. By using modulated light, researchers can tell how long it takes for the light to travel through the tissue as well as how much light the tissue absorbs. This information can then be used to yield physiologically and structurally relevant information about the sampled tissue.

Other teams have used similar probes externally on the breast to image deeply embedded tumors. Dr. Ramanujam's group is putting the probe in the breast directly at the site of the tumor. By simply rotating the needle, the researchers can make the probe survey multiple areas in the breast and provide an immediate picture of suspicious tissue that should be biopsied.

When Dr. Ramanujam and her colleagues tested the probe on samples designed to resemble breast tissue, they found that the probe assessed the light-absorption properties of lumps ranging from 10 to 30 mm in size, which is within the range of lumps found in breasts. These researchers will begin testing the device on patients undergoing core needle biopsy in the near future.

No Side Effects

The fiber-optic probe does not produce any unwanted side effects. The light, although it comes from a tiny laser, does not heat up the tissue. The light is absorbed by pigments in the blood that are constantly circulating. Unlike mammograms, the probe works well in dense tissue, such as the breasts of young women. "The nice thing is the light is directed at the lesion and the needle is right where the lump is so it doesn't have to work through intercepting tissue," Dr. Ramanujam says.

The probe may work best when combined with another optical sensor for biopsy needles that Dr. Ramanujam and her colleagues are developing with funding from the National Cancer Institute (NCI). By detecting the different fluorescence properties of malignant and normal tissue, the NCI sensor has differentiated benign and cancerous breast tissue with 90 percent accuracy in preliminary tests.

Compared with the NIBIB-funded probe, the NCI probe does not reach as deep but it does analyze more molecules at once, Dr. Ramanujam says. “We don’t know which will prove to be the more effective approach but if we demonstrate they are complementary technologies we could use both,” she says. The result may mean that women confronting breast cancer will have a more accurate test to determine if their worst fears are justified.

References

Lubawy C, Ramanujam N. Endoscopically compatible near-infrared photon migration probe. Optics Letters 29:2022-24, 2004.

Breslin TM, Xu F, Palmer GM, Zhu C, Gilchrist KW, Ramanujam N. Autofluorescence and diffuse reflectance properties of malignant and benign breast tissues. Annals of Surgical Oncology 11:65-70, 2004.